Editorial

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1 Introduction

This special issue is dedicated to the current efforts of industrial design engineering researchers, who are aiming at developing theories, methods, tools and approaches for human centred design.

Obviously, current research activities in industrial design engineering cover a very wide spectrum, ranging from advanced support methods, tools and techniques, through innovative products with new functionalities and technologies, to enhancing the outcome of design processes by introducing the principles of sustainability, telematics, context management, or embedded intelligence, and establishing new ways of addressing the specific needs of users by user-orientated product design (design for all). In the last years, the focus has been shifting from traditional engineering modelling, analysis and simulation tools towards more designerly means, as well as towards new designerly research approaches. As representative examples of novel design assets, we may refer to tools supporting market studies, emotional engineering, usability simulation, life cycle prediction, sustainability forecasting, and advanced virtual and physical prototyping.

In this special issue, in a balanced way, attention is given to both creative design support and systematic conduct of design research. In the context of user centredness, the aspects and needs of designers and users are considered concurrently. The papers have been selected from the most relevant and best quality papers presented at the Seventh International Symposium on Tools and Methods of Competitive Engineering (TMCE

2008). They are thematically arranged in this special issue. The first three articles address various issues of cognitive understanding of humans and their mental representations. Then the following two articles bear on the perceptive understanding of product characteristics, in particular, their effects on human sensing and experiences. Finally, the last paper considers physically-driven behaviour at modelling product characteristics to support human activities.

2 Addressing cognitive understanding

In commercially available CAD systems, 3D models are usually built up from 2D sketches. Undoubtedly, there is a need for new visualisation techniques when products are supposed to be created and investigated using 'real 3D imagery'. The paper submitted by Opiyo and Horváth, entitled 'Exploring the viability of holographic displays for product visualisation', analyses the use of spatial visualisation technologies, especially holographic visualisation displays, in product engineering processes. It argues on the appropriateness of using holographic displays for interactive 3D product visualisation. Actually, the paper offers a thorough discussion of the added values of 3D imagery in product design and engineering. It also emphasises the benefits that 3D presentation devices can provide compared to 2D displays, i.e., to traditional computer monitors that are typically used for CAD modelling nowadays. The conclusions are based on results obtained from some interesting experiments and a detailed analysis of various displays, taking into account an almost exhaustive number of metrics. The authors introduced a heuristics for the evaluation of 3D displays. Their specific goal was to identify weak points and bottlenecks of a holographic display system. The feedback of a large number of expert users and the results of the heuristics-based evaluation were used to determine the main shortcomings of the current technology. Among these, mentioned is the lack of advanced interaction methods – a hot issue that is already known from the research in immersive 3D visualisation environments (e.g., CAVE-s).

The paper of Mengoni and Germani entitled 'A methodology for sketch analysis to support maintaining the design intent in virtual prototyping', concentrates on the aesthetic design of customer products. The paper argues that freehand sketches and physical prototypes are still widely used as a media to express product ideas of designers. However, it has been recognised that they are not able to maintain design intent for the whole product development process. The paper proposes an approach to preserve the intent of designer based on a smart technique. This involves the analysis of the mental mechanisms of idea generation and formalisation of the related descriptive models. As the authors' objective is to support aesthetic design, they considered the analysis of aesthetic features in recognising the designer's intent. They investigated the relationships between the lines and other sign elements contained in the sketches in order to facilitate feature recognition. Sketch analysis is supposed to provide information on how aesthetic features should be used in surface modelling, coherently with the design intent. Obviously, a large number of sketch elements make the intent recognition procedure complex and possibly uncertain. In addition to some semiotic rules, the authors also propose a method to build the structure of the created virtual prototypes.

The third paper by Georgiev et al., entitled 'A method for the evaluation of meaning structures and its application in conceptual design', contributes results to the research in systematic construction of meaning structures. In psychology, the structure of meaning refers to the way these meanings are mentally represented and (hierarchically) connected. The paper discusses a study in which two different nouns are presented to a designer to generate new product ideas. The quality of the ideas is tested against the similarity measures of the noun pairs in terms of originality and practicality. The significance of the presented work is underlined by the importance of understanding the meanings of products. Nevertheless, this research topic poses several challenges for design research. Actually, just a limited progress has been achieved in terms of getting insight in the processes underlying meaning attribution and meaning construction. It is argued that the conducted experiment provides insights in conceptual design and contributes to the development of a new design methodology. As far as meaning construction is concerned, design methodologies, in general, provide only a poor guidance for designers towards defining and embodying appropriate meanings in their products. The authors propose to distinguish between two types of meanings. The first type of meanings has to do with what products can do and how they must be used (e.g., use cues, functionality, etc.). The second type of meanings consists of the sensorial, social, cultural and symbolic qualities of products, such as friendly, modern, or strong. This interesting research topic needs more attention in the future – specifically, in terms of application of the theoretical insights to practical cases, where the design process pursue a clear goal and the design must meet certain requirements and satisfy design constraints.

3 Aiming at perceptive understanding

The fourth paper by Bordegoni et al., entitled 'Design and assessment of a 3D visualisation system integrated with haptic interfaces', presents a system for visuo-haptic visualisation. Haptic extensions of user interfaces are getting more and more popular in 3D visualisation systems. However, both front-projection and rear-projection suffer from interference and/or occlusion problems. In the system previously developed by the authors, a specific haptic technology was adopted and used for generation and evaluation of digital shapes. The experiments with designers explored limitations in terms of visual parallax and the working space of the hands. The reason of these was the fact that the object viewing space and the haptic operation space were not co-located. This was not ergonomically optimal, and therefore the authors initiated research into a new set up. The system set up proposed in this paper reportedly overcomes the above problems and provides a natural working environment for designers. Mirrors are applied to project the visual image from above the user's working space. The distorted image is corrected by some adjustment and tracking features. This arrangement of the system allows the user to stand in front of it, without creating a shadow with his body, and to work with the haptic tool as if it was a physical rake.

The fifth paper, entitled 'Aesthetic consequences of making car exteriors visually robust to geometrical variation', has been contributed by Forslund and Söderberg. This work intends to avoid the unfavourable visual effects of car exteriors caused by unintended geometric variations, which are usually introduced by imprecise manufacturing processes and assembly technologies. Visually robust design aims at reducing these effects on the visual appearance. The authors conducted empirical studies in order to find relationships between the visual design properties and their visual robustness. It is argued that visual robustness depends on the structure, form, colours and materials of the visible parts and that visual robustness can be achieved without compromising other aesthetic features of product shapes. It has been stated as a principle that the effects of manufacturing variation have little influence on the product experience if an observer cannot interpret geometrical deviations from an assumed shape. Visual sensitivity has been quantified by means of six different factors contributing to the communication of geometrical intent, such as split line segments and curvature continuity. The proposed method is the first available one to address this relatively unexplored research topic. It has been found that the geometries of visually sensitive cars have more angled shapes and contain a large number of sharp form details, whereas visually robust cars have rounded and smooth shapes.

4 Considering physical behaviour

The last paper is entitled 'Automation of flexible components virtual prototyping: methodology, tools and validation'. Submitted by Raffaeli et al., this paper presents a comprehensive approach to a frequently occurring practical problem in mechanical engineering design. The kernel problem is virtual prototyping of flexible components of mechanical assemblies. This cannot be realised without considering their physically governed behaviour together with other product and process characteristics, such as the rules of correct installations. The paper discusses the major theoretical and computational considerations for the software tool developed for a comprehensive virtual prototyping. The tool supports definition of the typology and simulation of the physical behaviour of the components, as well as the calculation of the deformations and verification of the assemblability assimilability. The proposed tool can be integrated with various CAD packages. In order to support virtual prototyping, it includes an object oriented knowledge-base and calculates the deformed shape of the flexible components by a finite element analysis module. This module is connected to the used CAD software in a bi-directional way, and makes it possible for the designer to assess the design context correctly and to make the most appropriate decisions. The proposed tool offers benefits for designers of assemblies with uniaxial components, such as oleo hydraulic circuits for mining equipments, agricultural harvest machines, and multifunctional tractors.

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